# A new moonquake catalog from Apollo 17 geophone data

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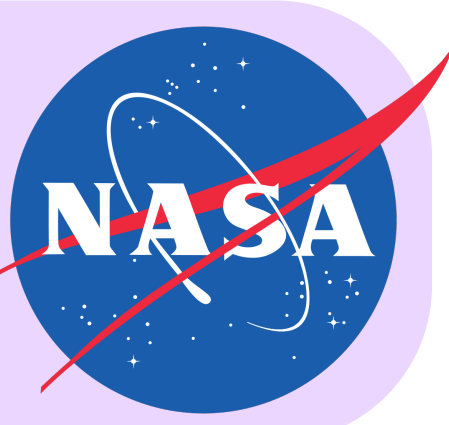
Summary

1) The Apollo 17 Lunar Seismic Profiling Experiment (LSPE)* operated in 'listening mode' for ~250 days, yet this dataset has not been systematically analysed for moonquake events (**Figure 1**).

2) We created an event catalog using the Hidden Markov Model (HMM) automated detection technique (**Figure 2**).

3) We have made about 50,000 detections from 3 different event templates. The detections are periodic, and have different temporal characteristics depending on template type (**Figure 3**).

4) Hand-picked Apollo 17 events correlate well with 'n1' HMM events as well as the diurnal signal in the Apollo heat flow data **(Figure 4).**

5) We are looking for ways to use this dataset to better understand lunar surface processes such as regolith production.

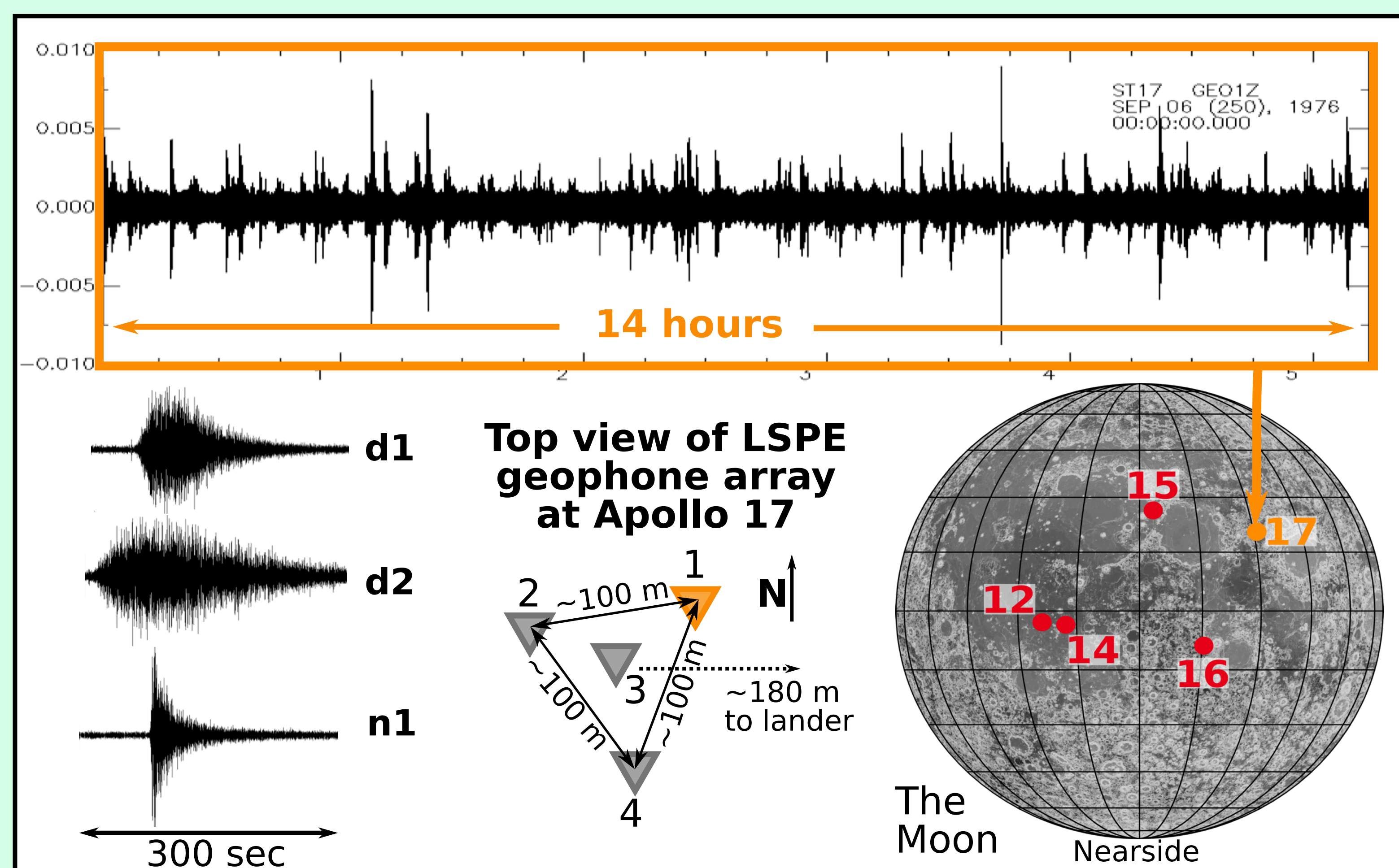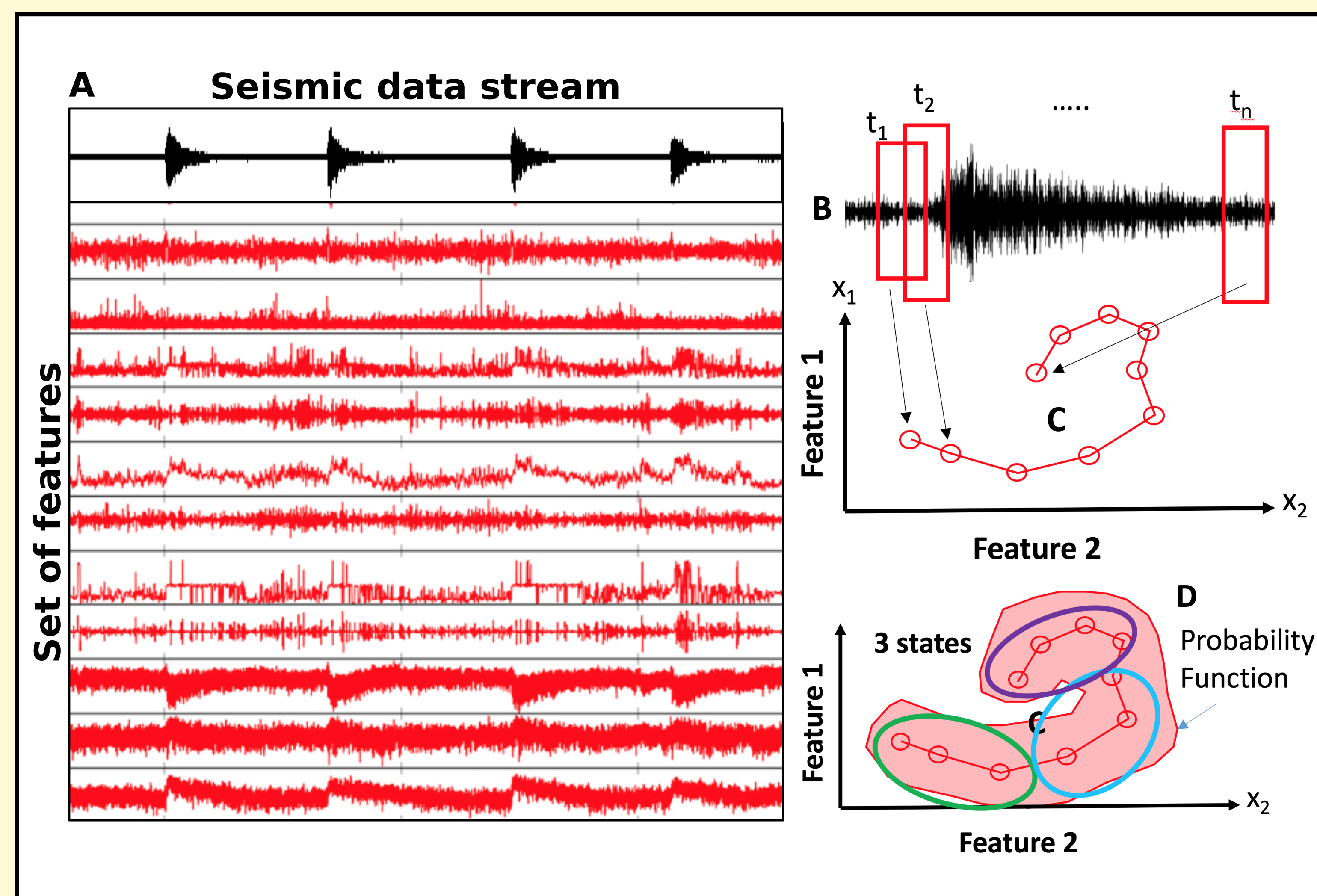## Apollo 17 'listening mode' seismic data

Figure 1. Apollo 17 LSPE example data from geophone 1. Data were filtered, despiked, demeaned and detrended to provide a 'continuous' input dataset. Three different event type templates were extracted from the continuous dataset (d1, d2 and n1).

Automatic catalog creation using the Hidden Markov Model (HMM) technique

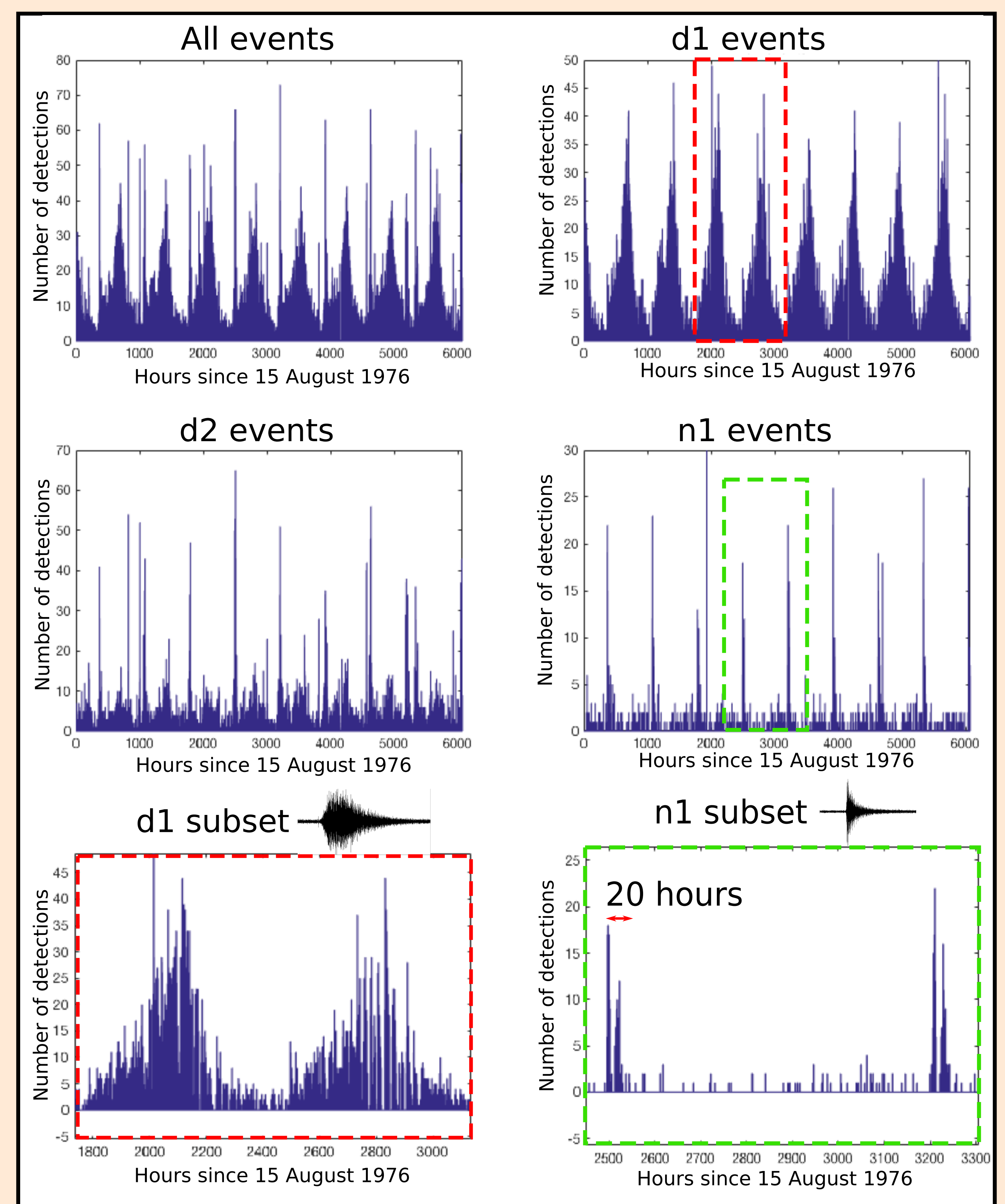## Detections per hour for 250 days of Apollo 17 LPSE 'listening mode' data

Figure 3. Histograms showing the number of HMM catalog detections over 8-months of passive-mode Apollo 17 geophone data.

Hand-picked detections versus Apollo 17 heat flow data
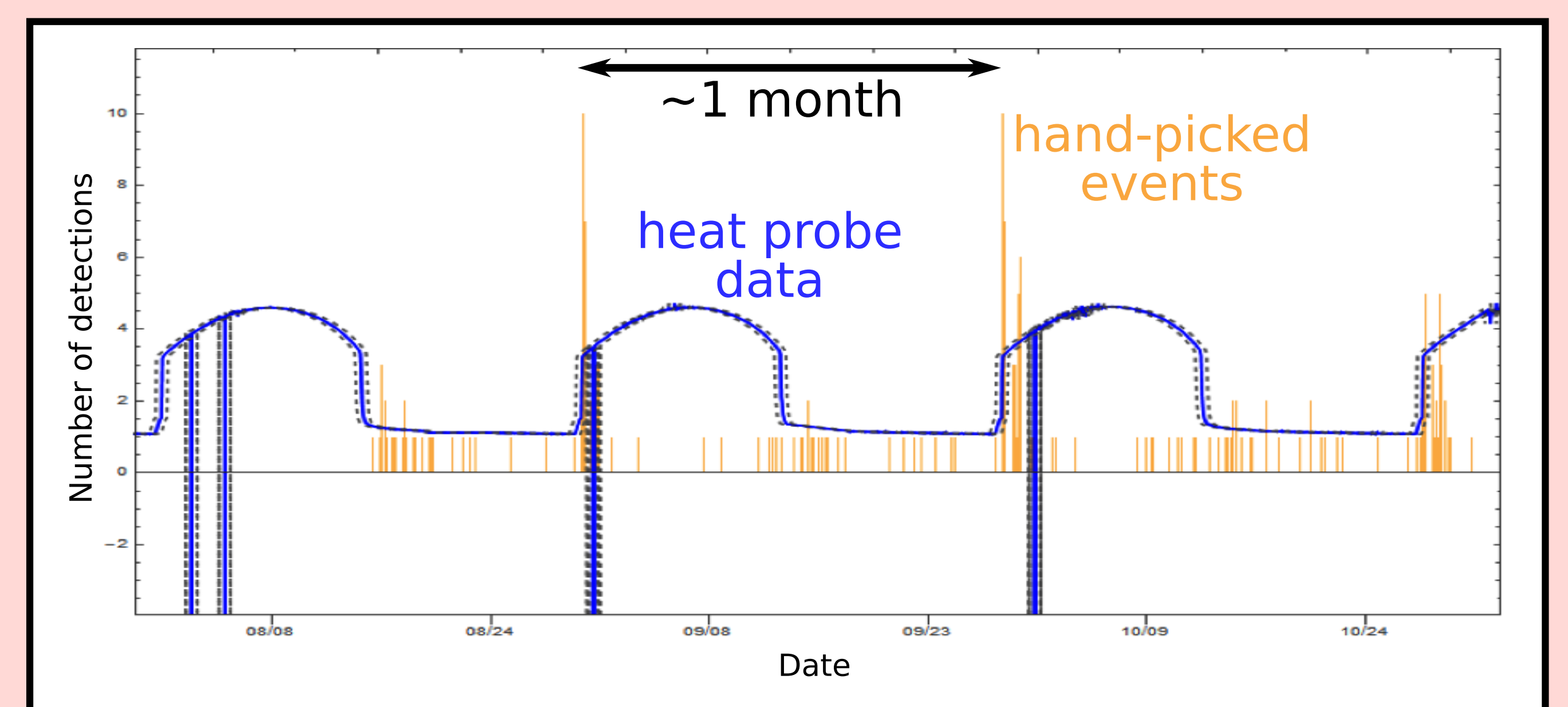

Figure 4. Sunrise peaks in the heat flow data** align with the peaks of the hand-picked moonquake data. The hand-picked moonquake data mostly reflect 'n1' event detections, which are generally the highest amplitude.

Figure 2. A 'target' event can be represented as a set of states and probabilities, which can be searched for in the full seismic volume to find other similar (though not necessarily identical) events and thus form a catalog. **A**) A continuous data stream is represented as a set of features (in red). **B**) Features for a given 'target' event (e.g. n1, d1, d2) change over time with respect to one another. **C**) Their evolution traces a unique path in n-dimensional feature space. **D**) The path is then modelled as a sequence of multidimensional PDF's.

*LSPE dataset courtesy of Yosio Nakamura. **Heat flow data are from Langseth et al. 1976, courtesy of Matthew Siegler and Richard S Miller.